Digital Twin Description:

The physics based, simulation-driven Digital twin leverages co-simulation methods with geometry-based 3D CAE tools, and system modelling approaches to replicate physical engineering devices. The 1 DOF Copter has been designed to simplify the intelligent control strategy of flight systems, flight dynamics and enables users to experience the fundamental concepts of quadcopters, rockets, hovercrafts, and underwater vehicles. Ready to use courseware enables students to understand the main topics of control engineering such as system modelling, linear control system design and simulation with the help of Altair Activate and Altair Inspire Motion. The fully open-source software gives the freedom to students and researchers to modify the algorithm or even design their own structure.

The Digital Twin allows the user to simulate the motion analysis in Activate while using the same PID controller for 3 different Plants: The real model, the transfer function and Co-simulation. With the Digital Twin you can control the real model or visualize the simulation digitally if the hardware is inaccessible.

- For the real model simulation, Acrome's Arduino based control system is used to control the 1DOF copter. The DC motor is located on one side of the balancing beam and the balancing block is located on the other side of the beam. When the propeller rotates, the balance beam moves through the pitching axis. The encoder is placed in the center of the bar for position reading. The user provides an angular input, and the fan rotates with varying rpm to reach that position and the encoder acts as a feedback system. In the control system, the angular inputs are converted into PWM (Pulse Width Modulation) and is fed into the Arduino ports while having the encoder constantly compute the angle of the beam.

- To obtain the model of the system, La Place transform is applied to the moment equation of the copter in order to calculate the transfer function (TF) of the model. The function of the TF is to replicate the behaviour of the real or co-simulation model. This is a faster method for testing or modifying the control system without running the co-simulation several times, which could take several minutes for each run.

- Cosimulation integrates the Inspire Motion model of the 1DOF copter and enables the user to control it through Activate. With the given CAD model, an actuator replicates the force generated by the lift force of the fan and in place of the encoder, an angular measure is used to calculate the angle of the beam. In Activate, the angular inputs are converted into PWM and then into force using the same controller and gains. The force is then fed into the plant (Inspire Model) giving angular values as the output.